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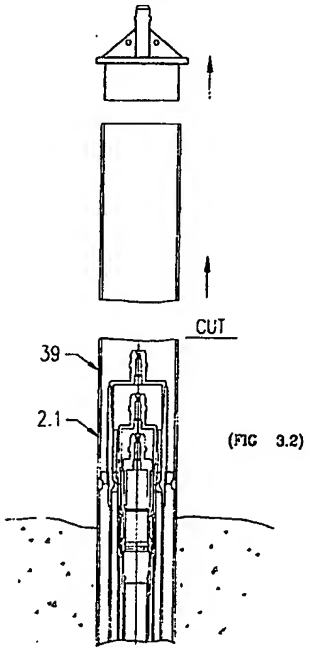
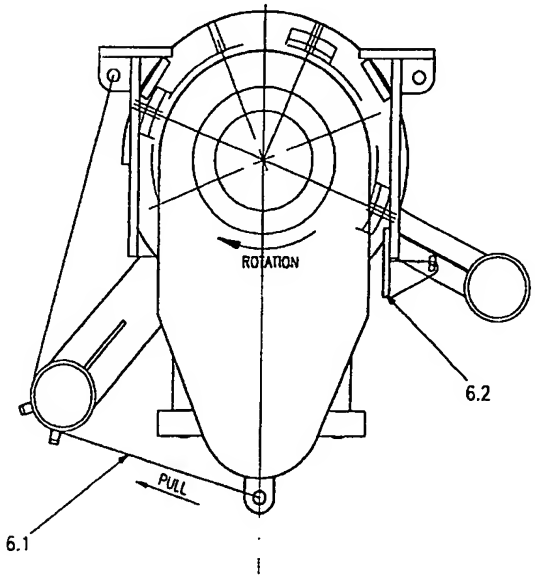
(54) Abandonment of offshore oil wells

(57) A method and apparatus for abandonment of an underwater well head which includes a strip of capped concentric casings (36) with at least one casing supported within another casing by a suspension arrangement, comprises explosively severing the casings a pre-defined distance below the mud-line (37). To achieve this one or more caps (38) are removed from a relevant casing or casings by application of rotational torque to the cap and reacting such torque to an outermost casing (39), using a torque reaction tool (40) secured to the top of the casing (39) and having a platform (41) to receive a hydraulic tongs (42). The tongs (42) serve to apply rotational force to the shaft (43) of a tool (44) engaged with the cap with the torque reaction of such force being taken-up by a cable attached between the tongs (42) and the reaction tool (40) and co-acting with abutments (45) so that the torque is transferred to act on the casing (39).



(FIG 3.2)

(FIG 6)



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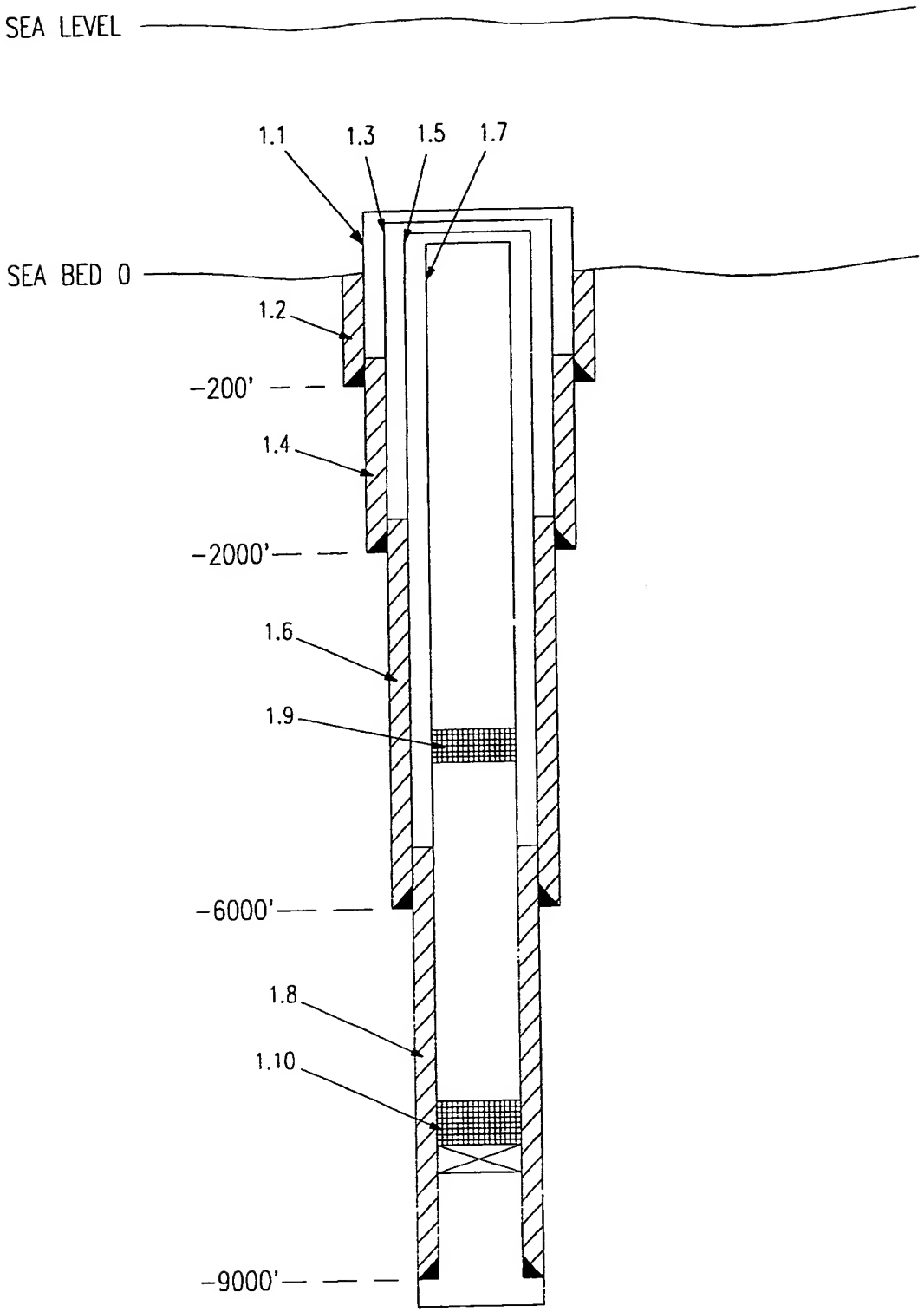
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

(FIG 1)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1.5
1.7
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1.9
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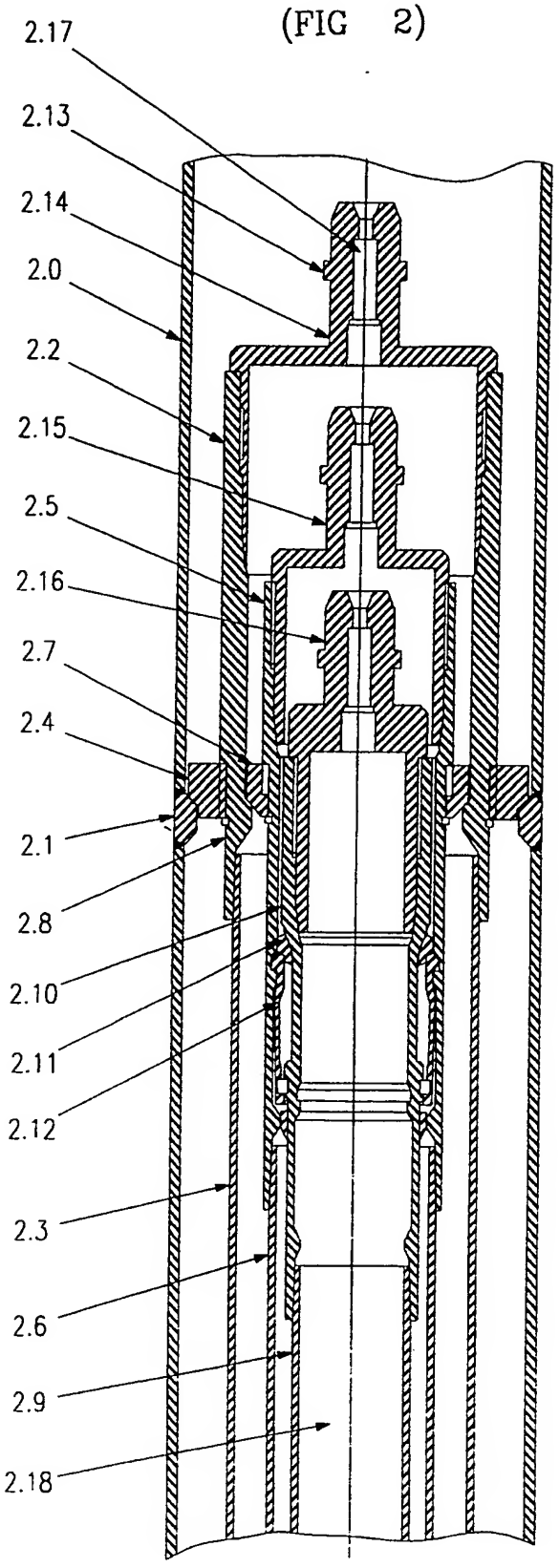
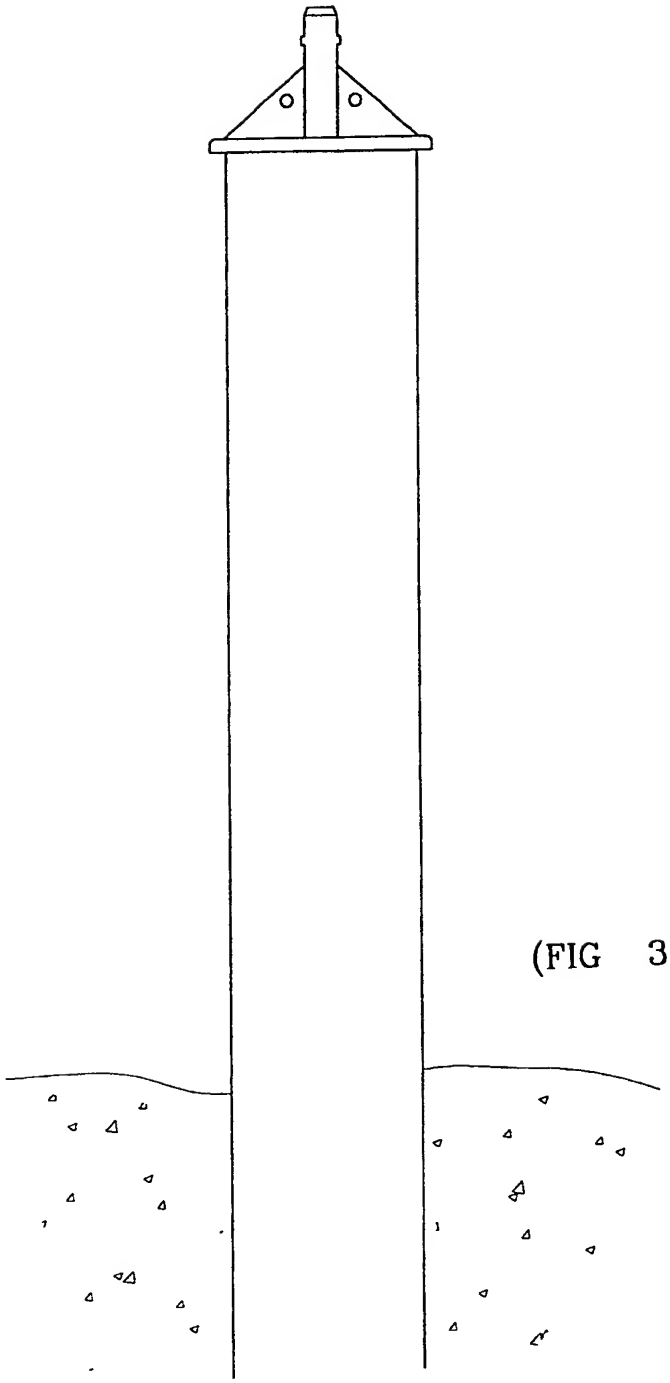
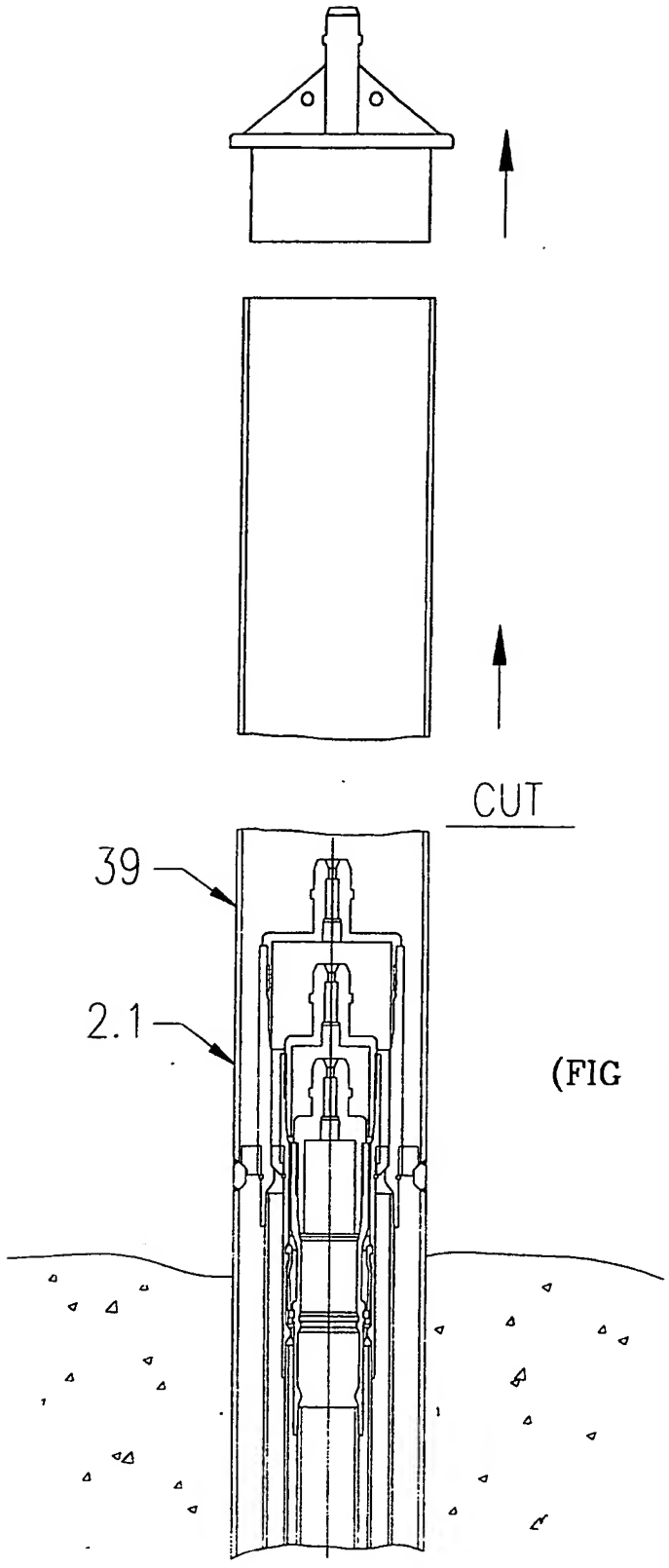
(FIG 2)

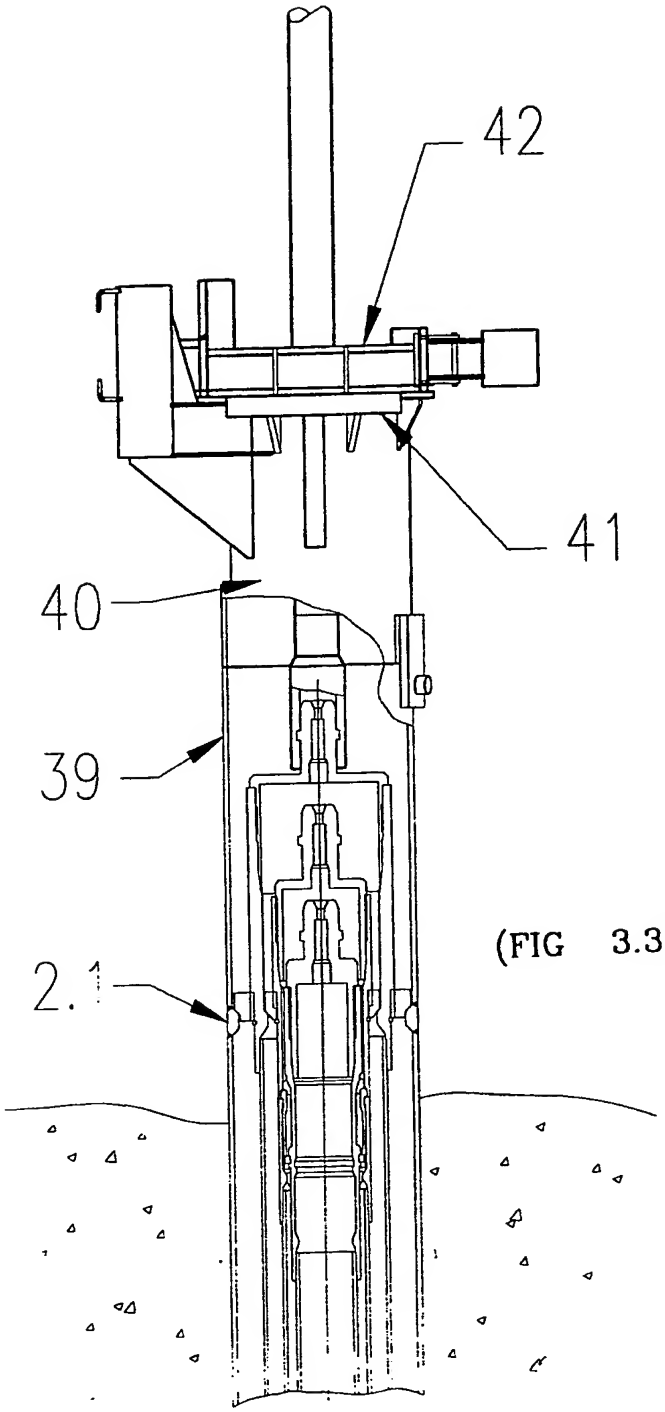




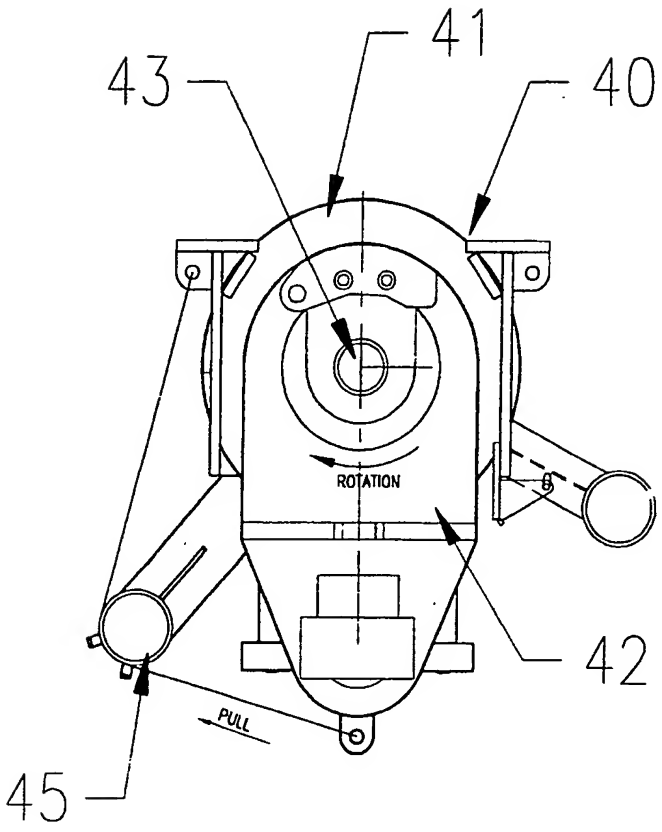
(FIG 3.1)



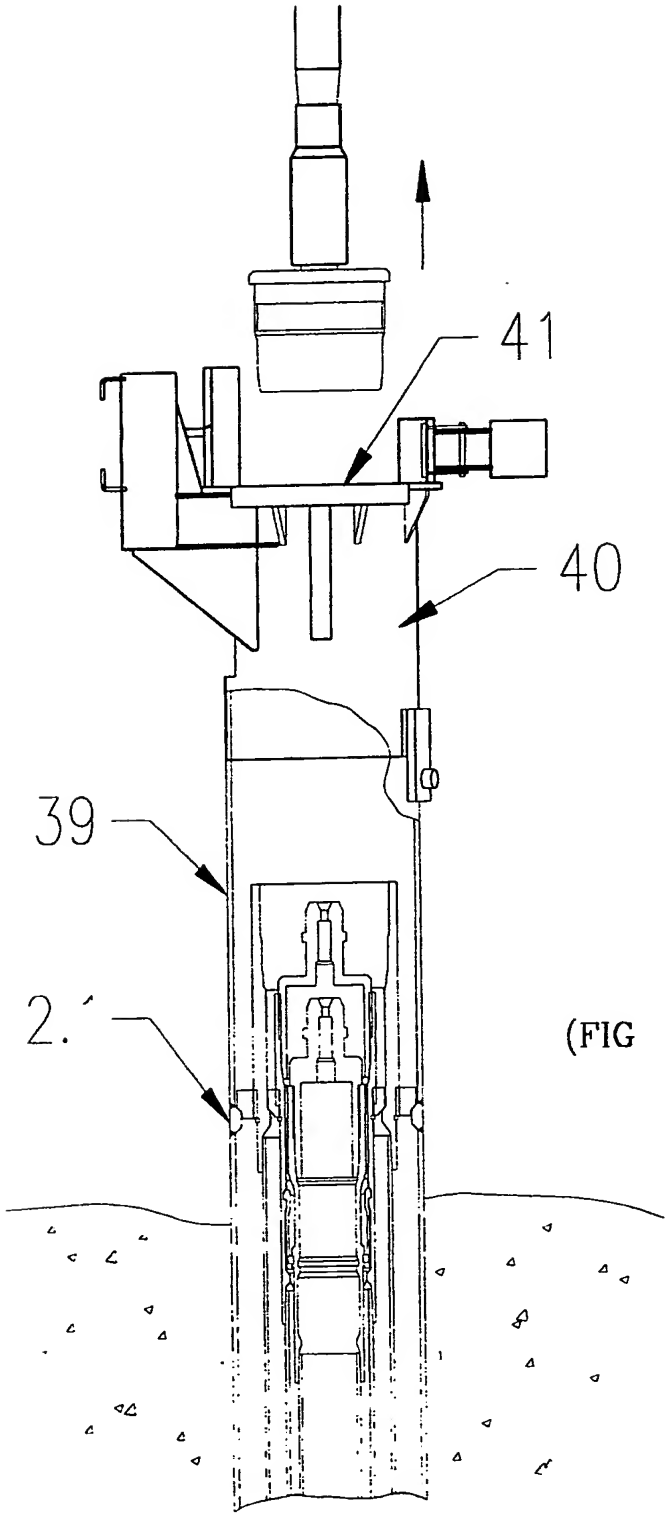
(FIG 3.2)



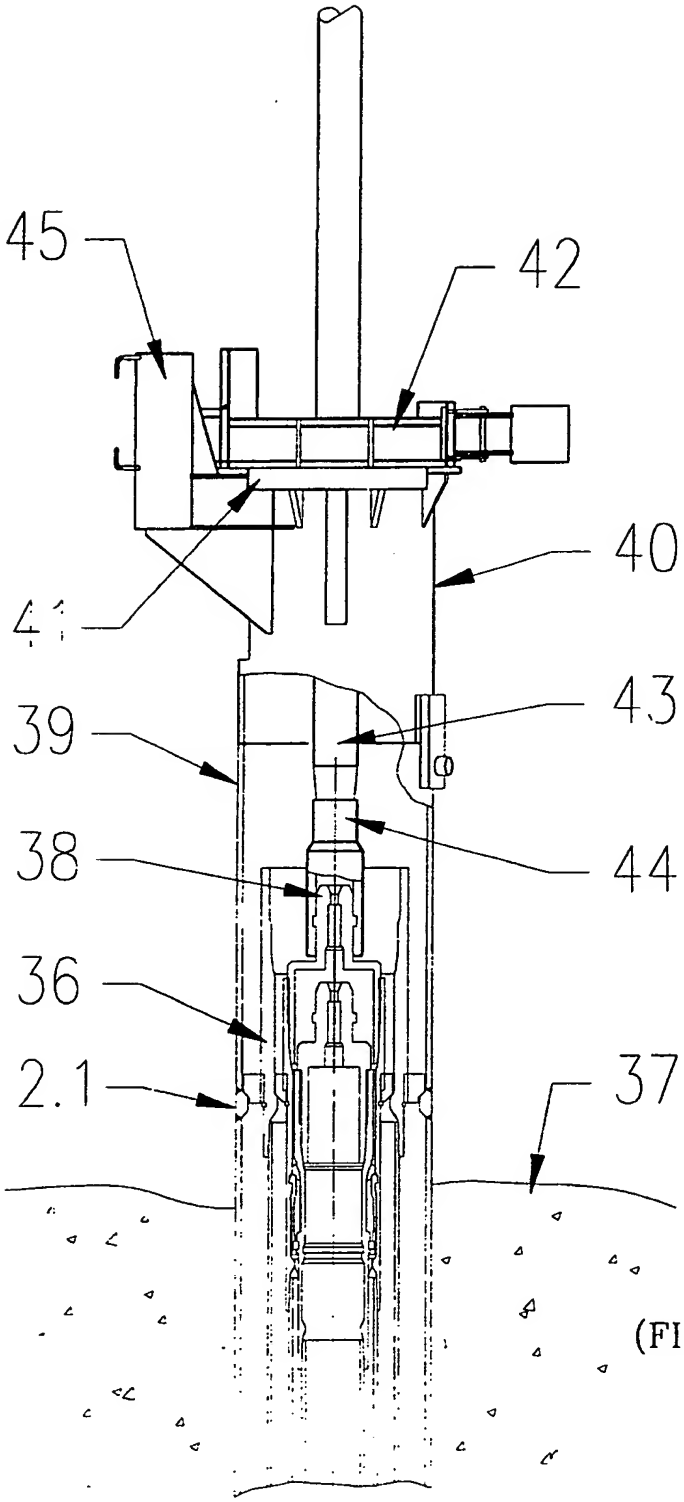
(FIG 3.3)



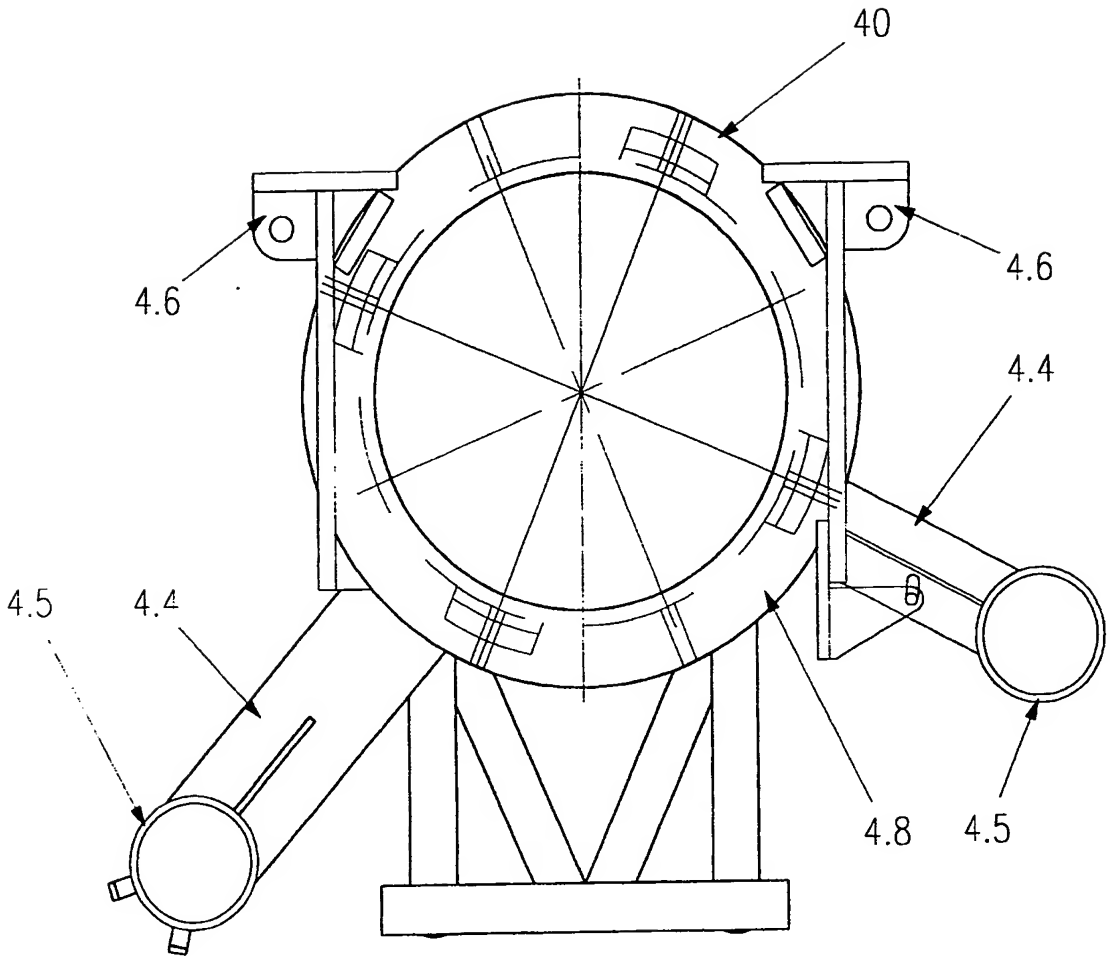
(FIG 3.4)



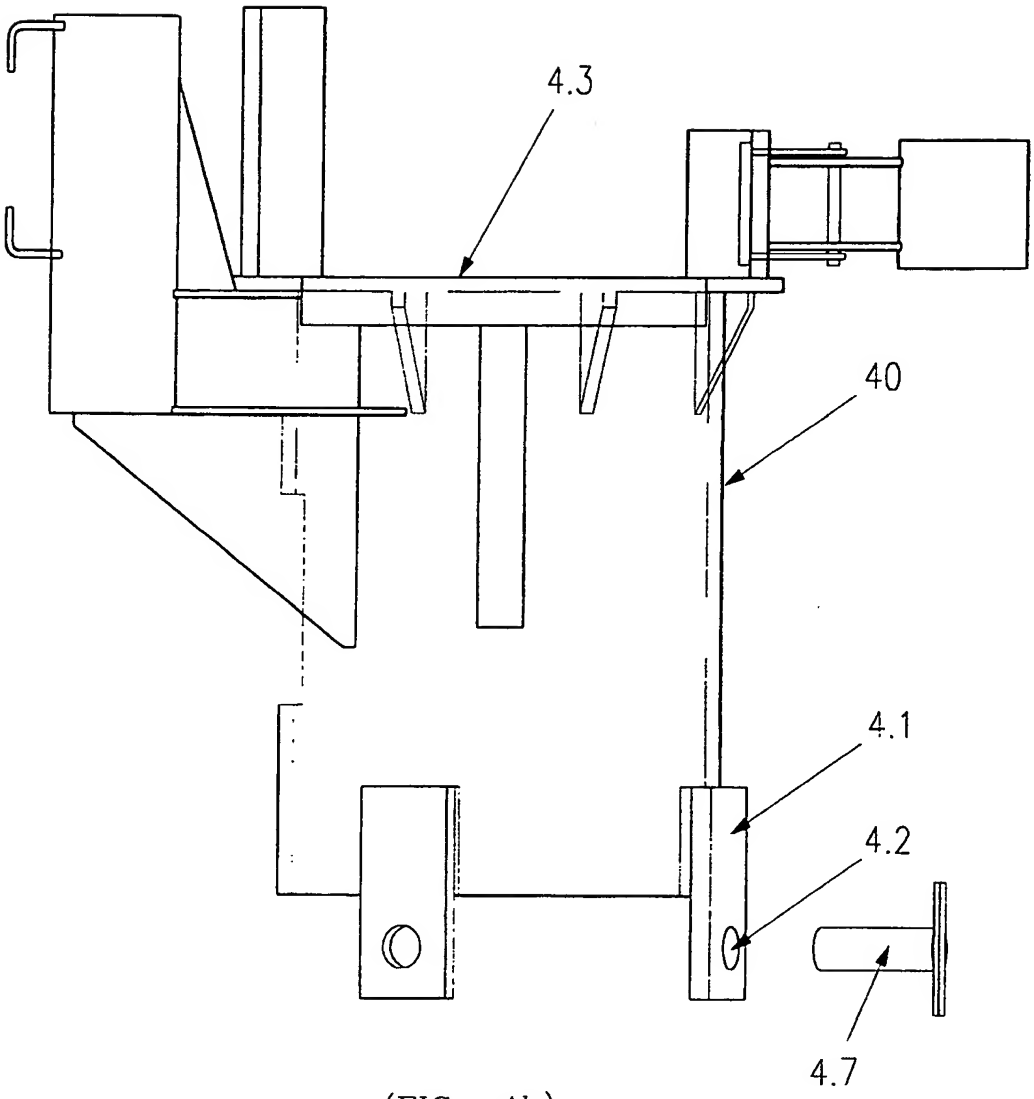
(FIG 3.5)



(FIG 3.6)

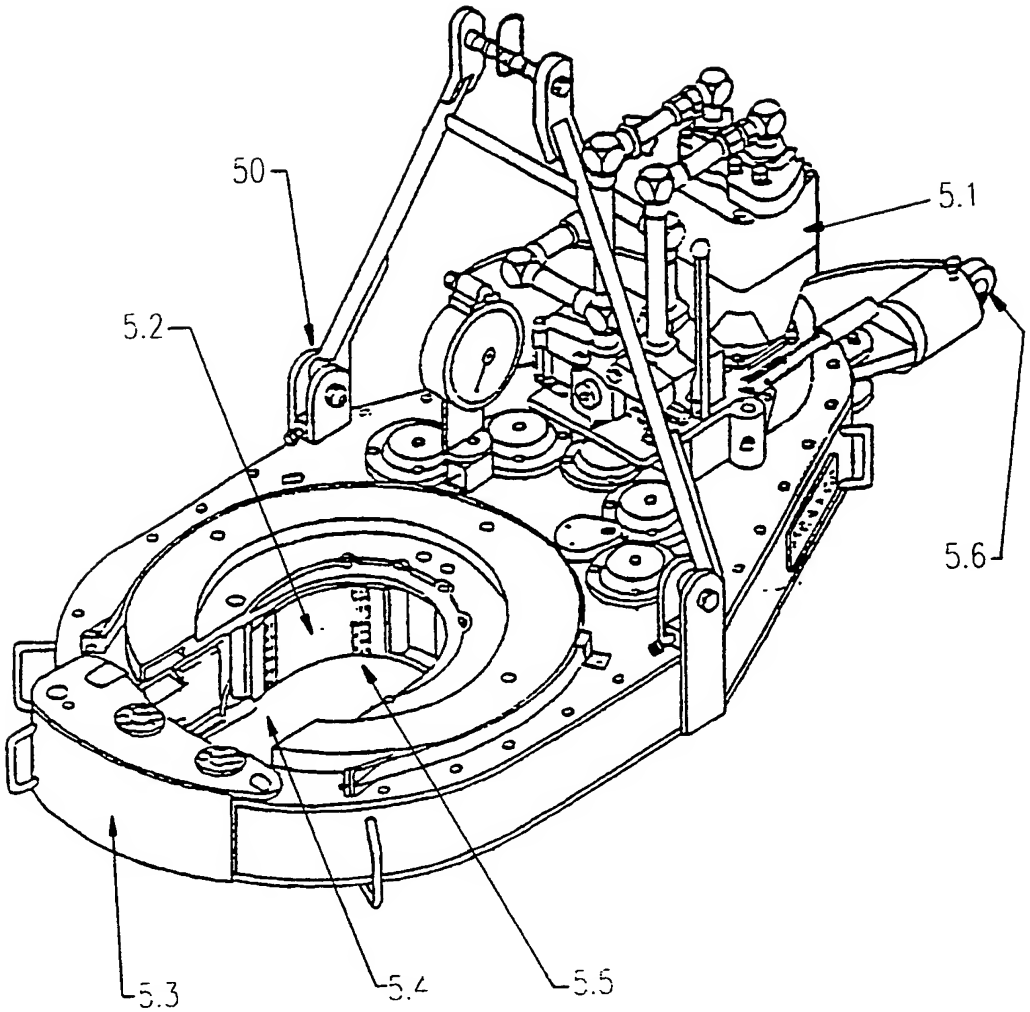


(FIG 4a)

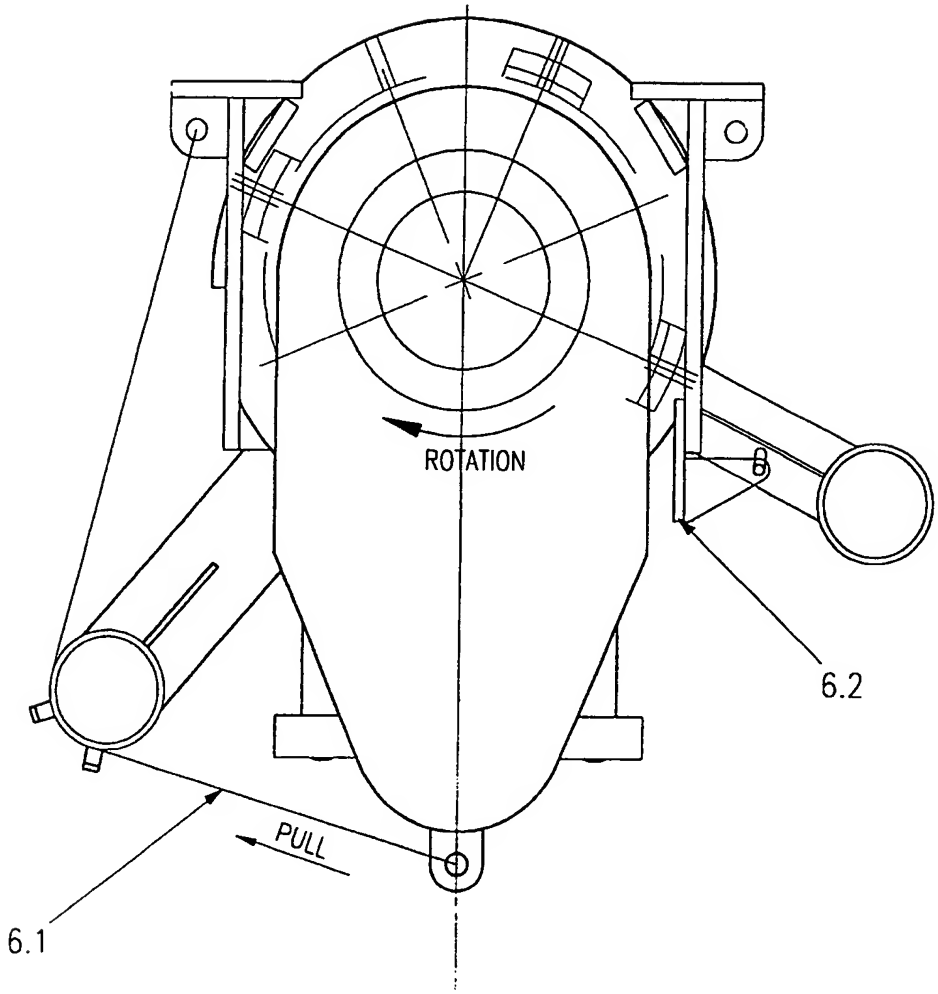


(FIG 4b)

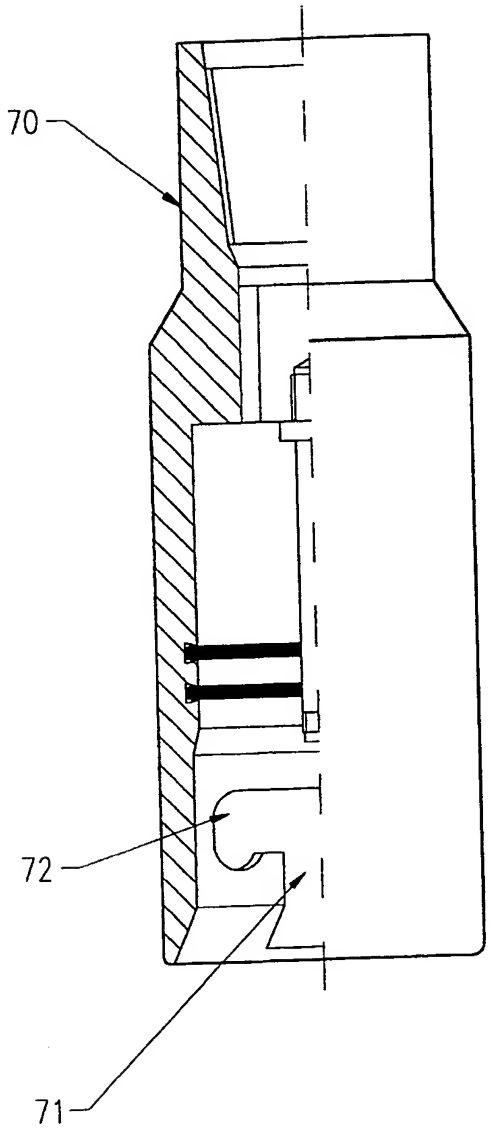
(FIG 5)



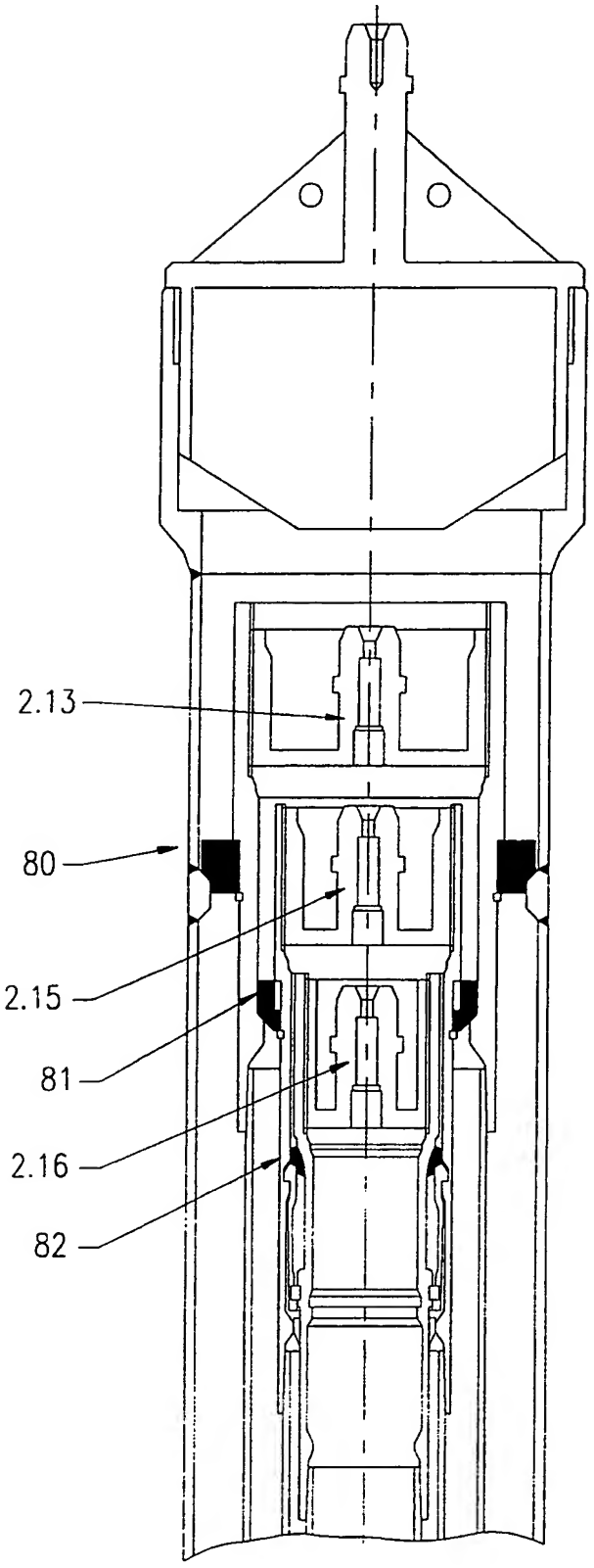
(FIG 6)



(FIG 7)



(FIG 8)



TITLE:

Abandonment of Offshore Oil wells.

This invention relates to offshore oil wells and is more particularly concerned with a method of removing or installing temporary abandonment caps from or in offshore seabed oil well mud-line suspension systems.

An offshore seabed well head will comprise a number of concentrically located casings, each of which extends to progressively deeper levels and a typical installation may comprise a 30" outer casing (Conductor) which is cemented into the seabed to a depth of some 300' in which is located a 20" casing which is hung from a casing hanger which in turn rests on a support shoe or 'Buttweld sub' located approximately at seabed level inside the 30" conductor. The 20" casing may typically extend down some 1200' and within which a $13^{3/8}$" casing is located and supported by a similar casing hanger and support shoe arrangement either slightly above or below the 20" support. The $13^{3/8}$" casing extends down some 4000'. Within the $13^{3/8}$" casing will be a $9^{5/8}$" casing

extending down some 9000´ again supported by a casing hanger and support shoe arrangement adjacent to the $13^{3/8}$" hanger. At the lower extremity of the $9^{5/8}$" casing a central 7" casing may be suspended which may extend typically to some 12000´. The annular spaces between the concentric casings are cemented or grouted from the bottom of each casing to a predetermined depth above, generally up to and slightly above the level of the next outer casing in order to provide the required structural strength in the complete well assembly and to form a pressure retaining seal.

Temporary or permanent abandonment procedures for such well heads involves cementing and plugging the core of the innermost casings (i.e. the 7" & 9") at intervals and securing ´temporary abandonment caps´ (T.A. caps) to the upper ends of each of the casings followed by the fitting of a so-called "trash" cap to the top of the 30" casing which projects possibly some 6´ above the seabed or "mud-line".

The purpose of plugging the well is to ensure that it is secured from oil or gas seepage and the purpose of capping is to reserve the possibility of reopening the well at some later date and to preserve the seabed ´tie-

back' assemblies from corrosion. It will be understood that the normal well head fittings such as the so-called "Christmas tree" will already have been removed.

For complete abandonment of a well, U.K. legislation provides for the removal of the well head to a specified depth (currently 3 metres) below the mud-line together with clearance of all relevant debris and parts and fittings which may have been abandoned on the seabed. Where the mud-line suspension system is sited significantly below the mud-line, that is to say the connection points between the various concentric strings of casing are in excess of 3m below the surface, then it may be possible to cut through the outer 30" using conventional internal or external removal techniques to effect a suitable abandonment.

It has however been found that serious difficulties and potentially dangerous situations arise where the well head is positioned closer to or even above the mud-line as, in order to sever the well head at the specified distance below the mud-line, it is necessary to cut through the more inwardly located concentric casings. In being provided with such a task it has been found by calculation that the $13^{3/8}$" and $9^{5/8}$" casings are under

considerable tension by virtue of the length and the fact that such casings have been put in position and thereafter cemented from the bottom up to a certain point only leaving a considerable free length. Such load is transferred via the mud-line suspension hangers from each casing string to its outermost neighbour. Calculation shows that a typical $9^{5/8}$" casing may well contract by over 1 metre when cut and the forces involved in such a contraction from the $9^{5/8}$" and the $13^{3/8}$" makes removal by manual means from outside the 30" casing extremely difficult.

It is also a feature of such an operation that prior to either cutting into a casing or removing the T.A. cap from a tubing hanger, as the T.A. caps are for the most part designed to retain internal pressure, one must establish that the bore into which one is about to gain access is free from a buildup of either gas or oil pressure. The procedures associated with this invention permits for gauging of each bore for pressure via each T.A. cap's top check valve prior to any attempt to unscrew such cap. This would not be the case with a external cutting technique when seeking to abandon a well, and further establishes this technique as a safe and reliable method of well abandonment.

The exact position where the casing is to be cut is dependent upon the specified distance below the mud-line at which the well is to be abandoned and the distance relative to the mud-line at which the casing suspensions have been located during the drilling of the well. It should be appreciated that during the drilling of the well, precise location of the relevant suspension points between the concentric casings is difficult to define accurately and in addition, many older wells which are being abandoned were not set up with the required degree of accuracy nor with subsequent abandonment in mind.

It is one of the objects of this invention to provide a method and apparatus enabling offshore wells to be abandoned preferably to the requirements of any appropriate legislation by severing the casing strings and outer conductor at an appropriate depth below the mud-line and which will enable such cutting to be effected with reasonable safety below the mud-line suspension system.

A further object of this invention is to provide an apparatus by which a method of severing the casing strings may be effected in a simple and reliable manner by virtue of a mechanically reliable means of removing

T.A. caps, thereby providing access for an internal explosive abandonment charge.

According to this invention, there is provided a method for abandonment of an underwater well head which includes a string of capped concentric casings with at least one casing supported within another casing by a suspension arrangement, the method comprising severing the casings a pre-defined distance below the mud-line, which method is characterised by the steps of :

a) removing one or more caps from a relevant casing or casings by application of rotational torque to said cap and reacting such torque to an outermost casing preferably by means of a rigid reaction tool,

b) positioning a shaped explosive charge at a required depth within a casing or casings from which a said cap or caps have been removed,

c) detonating said charge to sever the casing and preferably further outer casings from the inside to the outside of the string, and

d) removing the severed casings upwardly from the mud-line.

In a more specific aspect of this invention the outermost

casing of the string, generally being the so-called 30" conductor, is cut or the trash cap thereof removed, to gain access to the capped internal strings. The problem then arising, which has been solved by the present invention, is to remove the temporary abandonment caps in one or more internal casings in a mechanically reliable fashion without recourse to surface operations or reacting such torque as is required to adjacent structures or adjacent dead-weights or seabed anchors. It will be appreciated that the caps in the various casings are inserted utilising the offshore drilling platform from the surface and such a means enables considerable torque to be applied in securing the caps. Hitherto there has been no reliable or formally engineered method or means which enables the caps to be removed from the seabed by divers although torque has been applied to well tooling by divers reacting hydraulic casing tongs either back to adjacent structures, seabed anchors or dead-weights. We have now found, surprisingly, that by engagement of a suitable reaction tool to the outermost conductor, into which is seated a conventional hydraulic set of casing tongs or other means of developing the required torque, sufficient torque can be applied to the temporary abandonment cap via the drill string or short extensions thereof and a suitable cap

landing and recovery tool (J- tool) to unscrew the cap by rotating the string and J- tool arrangement with the tongs or other means and reacting the resultant rotational forces back to the outermost conductor via the reaction tool. By this method the caps in the casings can be removed sequentially to gain access into the string at the required level to place the explosive charge.

According to this invention there is also provided a reaction tool apparatus for use in carrying-out the method, the tool comprising a cylindrical body, means at the one end of the body for operative force applying connection to an outermost casing of a well head, a transversely extending platform at the other end of the body for receiving a torque applying means, a torque reaction lug connection located peripherally of the platform and connected to the body, an abutment member located peripherally outwardly of the lug and angularly displaced relative thereto and connected to the body, and brace means one end of which may connect with the lug to pass around the abutment member and to connect, in use, with torque applying means positioned on the platform.

This invention provides further a method and apparatus for abandonment of an underwater well head which includes

a string of capped concentric casings with at least one casing supported within another casing by a suspension arrangement, the method comprising explosively severing the casings a pre-defined distance below the mud-line, characterised in that one or more caps are removed from a relevant casing or casings by application of rotational torque to the cap and reacting such torque to an outermost casing, using a torque reaction tool secured to the top of the casing and having a platform to receive a hydraulic tongs, the tongs serving to apply rotational force to the shaft of a tool engaged with the cap with the torque reaction of such force being taken-up by a cable attached between the tongs and the reaction tool and co-acting with abutments so that the torque is transferred to act on the casing.

One of the advantages of the apparatus according to this invention is that it is able to accommodate any small displacements of the cap from the centre line of the well head which may occur through displacement and mispositioning of the hangers supporting the casing string. Due to the construction of the caps and the limited area available between the peripheral wall and a central boss, it would be difficult if not impossible to use cutting equipment to sever the caps to gain access to

the casing internally.

In the past, those skilled in the art have discarded diver or ROV operated methods of unscrewing the casing string caps as being unworkable or indeed impossible particularly in view of the tremendous torque that is applied in fitting the caps from the surface platform rig. Nevertheless we have found surprisingly that, by using an hydraulically operated power tongs arrangement reacting through a rigid reaction tool, not only can sufficient grip and force be applied to a tool engaging the cap but the outer casing has proved to be more than sufficient to use as a torque reaction fixture, thus enabling the necessary work to be carried out from the seabed without the high cost of employing a surface support vessel or self elevating drill platform with appropriate surface drilling apparatus rig to decap the casing strings in a conventional fashion.

Another aspect of this invention provides a method and apparatus for the capping and, if necessary, recapping of an abandoned well which method may be carried out at the mud-line suspension system itself through use of the apparatus disclosed herein. Such a method would be useful where inspection of the capping is required, or

replacement of faulty caps is required or the retrofit of caps where none had initially been fitted is a requirement.

The method and apparatus according to the present invention will now be described in more detail and by way of example with reference to the accompanying drawings illustrating a preferred method and preferred form of apparatus for putting the invention into effect.
Referring to the drawings :

Figure 1, shows diagrammatically a typical oil or gas well installation, specific to casing depths and cement depths,
Figure 2, shows in section the top and capped end of a string of casings referred to in the art as a "mud-line suspension system",
Figure 3, in sub-Figures 3.1 to 3.6 show the initial six stages in a preliminary procedure for carrying out the method of this invention,
Figures 4a and 4b, show respectively plan views and side elevations of a torque reaction assembly (reaction tool) for fitment to the top of the outer 30" conductor,
Figure 5, shows schematically a typical set of hydraulic power tongs for application of torque to the

cap removal tool,

Figure 6, shows in plan view the apparatus of Figure 5 positioned on the torque reaction assembly (reaction tool) of Figure 4.

Figure 7, illustrates a construction of so-called J-tool and,

Figure 8, shows schematically a mud-line suspension of a so-called "stack-down" construction.

Referring firstly to Figures 1 and 2 of the drawings, these illustrate a typical well construction comprising a string of concentric casings descending from a so-called mud-line suspension system located on the seabed. Figures 1 and 2 are only exemplary of a typical installation. Referring firstly to Figure 1 of the drawings, the well head comprises an outer 30" conductor 1.1 which extends to a depth of some 200´ and which is embedded in a cement reinforcement 1.2 from it´s lower extremity up to the seabed. Concentrically located within the outer casing 1.1 is a 20" casing 1.3 which extends to a depth of some 2000´ and which is provided with a cement infill 1.4 extending upwardly from the base of conductor 1.1 up to the cement reinforcement 1.2 or indeed to up to seabed. The next concentric casing 1.5 has a 13" diameter and extends down to 6000´ with a

cement infill 1.6 extending up to the infill 1.4 from the base of casing 1.3. Finally a 9" casing 1.7 is provided extending down to 9000′ with a cement infill 1.8. The well top may be typically be some 70′ to 180′ below sea level and 5′ to 15′ above seabed level. When such a well is abandoned cement plugs are placed within the inner casing 1.7, for example a cement plug 1.9 may be provided at about the 3000′ level and a cement plug 1.10 provided at the 8500′ level. The three innermost casings 1.7, 1.5 and 1.3 will be mechanically capped at or below the seabed or mud-line with so called temporary abandonment or corrosion caps and a so-called trash cap may be provided over the outer 30" conductor 1.1.

Referring now to Fig 2 also the outer 30" conductor 1.1 incorporates an internal abutment, ledge, landing ring or so called buttweld sub 2.1 which supports a mud-line casing hanger 2.2 which is attached to the 20" casing 2.3. The support is effected through an intermediate annular part 2.4 which is seats on the abutment 2.1. In a similar manner the mud-line casing hanger 2.5 of the 13" casing 2.6 is supported by the annular intermediate part 2.7 which abuts and seats on the internal abutment 2.8 on the casing hanger 2.2. The 9" casing 2.9 is supported by mud-line casing hanger 2.10 which engages

the hanger 2.5 through connections and seals shown generally as 2.11 and 2.12.

The outer 30" conductor 1.1 will normally be closed by a relatively easily removable cap, referred to as a trash cap, to prevent ingress of debris and other contaminating matter and in some cases to retain corrosion inhibiting fluids. Such a cap would not be intended as a structural unit or pressure retaining item and is readily removed by divers.

The 20" casing hanger 2.2 is closed off by means of a screw fitted cap 2.14 (20" T.A. cap). This cap will be installed by the surface drilling platform and should be screwed home to a specified torque using a 'J-' tool 70 (see figure 7) deployed from the surface rig and having three bayonet-type slots 71 each of which locates down onto engaging lugs 2.13. The lugs 2.13 then seat into locking extensions 72 to provide positive engagement. In a similar way, the 13" hanger 2.5 is closed by a cap 2.15 (13" T.A.Cap) and lugs similar to 2.13. The $9^{5/8}$" hanger 2.10 is closed by means of a similar screw fitted cap 2.16 ($9^{5/8}$" T.A.Cap). Each T.A. in the given example is provided with a valve assembly 2.17 which closes the venting passageway.

Currently, wells which are to be permanently abandoned in the U.K sector have to be severed a minimum of three metres below the natural seabed.

If the uppermost mud-line suspension hanger is placed well down the outer 30" casing 1.1 during abandonment of the well, then conventional methods and cutting procedures could be used to remove the 30" conductor only at the minus 3m level. However, recent changes in abandonment philosophy tend to require all T.A Caps to be removed prior to permanent abandonment. In certain cases, cutting may need to be done below the suspension abutment 2.1, 2.8 and 2.12. Due to the length of free casings and their weight the $13^{3/8}$" casing 2.6 and the $9^{5/8}$" casing 2.9 are under considerable tensile load and calculations indicate that in a typical well the load is such that over one metre contraction could occur following cutting. If the various cap members 2.14, 2.15 and 2.16, were arranged so that their position was above the 30" conductor abutment hanger 2.1, then conventional underwater steel cutting could as a contingent procedure, proceed through the casing parts in order to obtain free access to the $9^{5/8}$" casing bore to insert an explosive charge which could be detonated remotely to sever the casing from the inside outwards at the appropriate 3

metre below seabed level. However, in some mud-line suspension system arrangements as may be seen from Figure 8, so called 'stack-down' constructions are encountered where the caps cannot be removed by a cutting process without also destroying the suspension points 80,81,82 which would result in the considerable tensional loads being suddenly relieved.

The present invention provides a method and apparatus to now be described which overcomes these disadvantages with the result that the invention can be arranges to be universally applicable and applied regardless of the precise construction of the abandoned well head to be serviced.

For the initial operation, a surface vessel will locate the well and deploy a conventional remotely operated vehicle (ROV) to inspect the well location and to carry out an initial survey. Next, divers will be deployed to clear any debris from the outer 30" casing and to locate the outer casing butt weld suspension point 2.1 which generally will be at or above the mud-line but if this is not the case, excavation is effected to expose same. In the case of mud-line suspension systems set considerably below the mud-line, the inspection would be undertaken by

a video camera device lowered into the 30" conductor.

Referring now to Fig.3 if required and in order to set the reaction tool as close as possible to the 20" T.A.Cap, any 30" trash cap would be removed Fig. 3.1 and the 30" conductor may be circumferentially cut down by conventional underwater steel cutting techniques Fig. 3.2.

The next stage is to fit a torque reaction assembly (reaction tool 40 see Fig. 4) on to the top of the 30" conductor 2.1 and as shown in Figure 3.3 and this sits on the top of the cut end of conductor 2.1 using three attachment yokes 4.1 which are secured by means of pins 4.7 passing through holes 4.2 in the yokes which correspond with holes cut or bored through the conductor 2.1. The torque reaction assembly 40 has a cylindrical body with a top plate surface 4.3 with laterally extending arms 4.4 provided with abutment tubes 4.5 and reaction lugs 4.6. The assembly 40 is adapted to receive a hydraulically operated power tongs unit 50 as shown in Figures 5 and 6. The power tongs unit 50 sits on the top plate surface 4.3 and comprises a body supporting a hydraulic drive motor 5.1 with jaws 5.2 which are in the nature of tongs and latch gate 5.3 which may be swung

open to permit a shaft to be entered through the slot 5.4 and into the central area 5.5 embraced by the jaws of the tongs. See also figure 3.4.

The reaction tool assembly 40 is used to effect removal of one or more of the caps 2.14, 2.15 or 2.16 by using a suitable tool which engages the lugs 2.13 on a cap with the shaft of the tool extending upwardly through the area 5.5. Figs. 3.3 to 3.6 refer. When the power tongs assembly is operated through the hydraulic motor drive 5.1 and by means of suitable internal gearing, the jaws of the tongs 5.2 clamp tightly around the shaft and by virtue of a camming system, the bite grips the shaft in a slip-free manner and enables a considerable torque to be exerted on the shaft. The torque is taken up by reaction from a securement point 5.6 though a wire or chain brace 6.1 which passes around a tube 4.5 and is attached to lug 4.6. By this means, the torque reaction is thereby transmitted to the outer 30" conductor 2.1.
Surprisingly, it has been found that even the most forcefully inserted caps can be removed by virtue of the tremendous forces which may be exerted by the tongs unit 50 and which can be absorbed quite easily by the casing 2.1 and the torque reaction assembly 40 (reaction tool) fitted thereto. See also Figs 3.3 to 3.6.

In an alternative construction an articulated reaction fitment 4.8 is provided on the top plate 4.3 of the assembly 40 and this co-acts with a reinforced portion 6.2 provided on the relevant side plate of the tongs unit 50. In this alternative arrangement, torque reaction can be taken up directly without the need for a separate brace fitment. Both means of transferring torque from the tongs 50 to the reaction tool 40 are specifically designed to permit the tongs to rise with the T.A. caps as they unscrew whilst still maintaining optimum reaction directions and angles with each other.

This invention therefore provides a much simplified and reliable method for gaining free access to the $9^{5/8}$" casing bore 2.18 and effecting removal of the casing strings to the required depth below the seabed utilising an explosive charge and wherein the charge may be lowered into the most central of the casings forming the string to an appropriate depth after having exposed said casing by removal of the T.A. caps through a torque applying means driving a shaft with tool. This arrangement obviates the difficult or dangerous procedures involved in trying to cut through the relevant casing, casing hanger or T.A. caps in order to expose the bore thereof, the use of a surface drilling apparatus or the use of

less reliable alternative means of reacting the torque required to remove the T.A. caps such as securing back to deadweights or adjacent structures.

Following the successful explosive cutting of the $9^{5/8}$", 13" and 20" casing and the 30" conductor, which may be augmented by a second explosive charge to sever through the outer casing 2.1 if required, recovery of the well debris may be effected by pulling the 30" conductor 2.1 together with the internal strings in an upward direction using the surface recovery vessel.

Although specific and detailed techniques which would be used in carrying out the method of this invention may vary depending upon the nature and construction of the particular well to be abandoned or mud-line suspension system requiring remedial intervention, such variations will be obvious ones and within the spirit and scope of the present invention defined and exemplified herein.

CLAIMS

1. A method for abandonment of an underwater well head which includes a string of capped concentric casings with at least one casing supported within another casing by a suspension arrangement, the method comprising severing the casings a pre-defined distance below the mud-line, which method is characterised by the steps of :

a) removing one or more caps from a relevant casing or casings by application of rotational torque to said cap and reacting such torque to an outermost casing,
b) positioning a shaped explosive charge at a required depth within a casing or casings from which a said cap or caps have been removed,
c) detonating said charge to sever the casing and preferably further outer casings from the inside to the outside of the string, and
d) removing the severed casings upwardly from the mud-line.

2. A method according to Claim 1, wherein the torque is reacted to an outermost casing by means of a rigid reaction tool.

3. A method in accordance with claim 1 or 2, wherein a reaction tool is engaged with the outermost casing into which tool is located a hydraulically operated set of tongs or other means of applying torque to a cap via a landing and recovery tool (J- tool) to unscrew the cap by rotating the J- tool with the tongs or other means and reacting the resultant rotational forces back to the outermost casing via the reaction tool.

4. A method in accordance with any preceding claim, wherein the caps in the casings are removed sequentially to gain access into the string at the required level to place the explosive charge.

5. A method in accordance with any preceding claim, wherein the reaction tool is positioned concentrically over the casing and connected to said casing to form an integral extension thereof, a lateral extension of the tool forming an abutment member against which the torque reaction for removal of a cap is applied.

6. A reaction tool apparatus for use in carrying-out the method of any preceding claim, the tool comprising a cylindrical body, means at the one end of the body for operative force applying connection to an outermost

casing of a well head, a transversely extending platform at the other end of the body for receiving a torque applying means, a torque reaction lug connection located peripherally of the platform and connected to the body, an abutment member located peripherally outwardly of the lug and angularly displaced relative thereto and connected to the body, and brace means one end of which may connect with the lug to pass around the abutment member and to connect, in use, with torque applying means positioned on the platform.

7. Apparatus in accordance with claim 6, wherein the body of the reaction tool is located on the top of the casing and secured using peripherally spaced attachment yokes which are secured by means of pins passing through holes in the yokes which correspond with holes cut or bored through the casing.

8. Apparatus in accordance with claim 6 or 7, wherein the torque reaction tool assembly has a cylindrical body with a top plate surface with laterally extending arms provided with abutment tubes and reaction lugs, the assembly being adapted to receive a hydraulically operated power tongs unit, the power tongs unit sitting on the top plate surface and comprising a body supporting

a hydraulic drive motor with jaws which are in the nature of tongs and a latch gate which may be swung open to permit a shaft to be entered through the slot and into a central area embraced by the jaws of the tongs.

9. Apparatus in accordance with claim 8, wherein the reaction tool assembly effects removal of one or more of the caps by using a tool which engages the lugs on a cap with the shaft of the tool extending upwardly through the platform area to be engaged by the tongs.

10. Apparatus in accordance with claim 9, wherein the power tongs assembly is operated through a hydraulic motor drive and by means of internal gearing, the jaws of the tongs clamping tightly around the shaft by means of a cam arrangement, the bite griping the shaft in a slip-free manner to enable torque to be exerted on the shaft, the torque being taken up by reaction from the securement lug point on the tongs through a wire or chain brace member which passes around a tube and is attached to the lug whereby the torque reaction is thereby transmitted to the casing.

11. Apparatus according to any preceding claim 6 to 10, wherein an articulated reaction fitment is provided on

the top plate of the assembly which co-acts with a reinforcement provided on the relevant side plate of the tongs unit.

12. Apparatus according to Claim 11, wherein the torque reaction is taken up directly without the need for a separate brace fitment.

13. Apparatus in accordance with any preceding claim 6 to 12, wherein the means for transferring torque from the torque applying means to the reaction tool is arranged to permit the torque applying means to rise with the cap being removed as same unscrews whilst still maintaining optimum reaction directions and angles with each other.

14. A method and apparatus for abandonment of an underwater well head which includes a string of capped concentric casings (36) with at least one casing supported within another casing by a suspension arrangement, the method comprising explosively severing the casings a pre-defined distance below the mud-line (37), characterised in that one or more caps (38) are removed from a relevant casing or casings by application of rotational torque to the cap and reacting such torque to an outermost casing (39), using a torque reaction tool

(40) secured to the top of the casing (39) and having a platform (41) to receive a hydraulic tongs (42), the tongs (42) serving to apply rotational force to the shaft (43) of a tool (44) engaged with the cap with the torque reaction of such force being taken-up by a cable attached between the tongs (42) and the reaction tool (40) and co-acting with abutments (45) so that the torque is transferred to act on the casing (39).

15. A method for the abandonment of an underwater well head substantially as herein described with particular reference to the drawings.

16. A method for use underwater and for the removal of a casing cap on a closed-off drill-string carried out substantially as described herein and illustrated.

17. Apparatus for the application of torque to remove a well head cap from a casing constructed and arranged to operate substantially as herein described with reference to the drawings.

The Patent Office

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.N): E1F (FLA)

Int Cl (Ed.6): E21B

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A,P	GB 2275282 A	(Halliburton Company) 24 Aug 1994	1
A	US 5107931	(Valka et al)	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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